Linking OMI Tropospheric SO_2 Measurements to Aerosol Production Using MISR on the EOS-Terra Satellite

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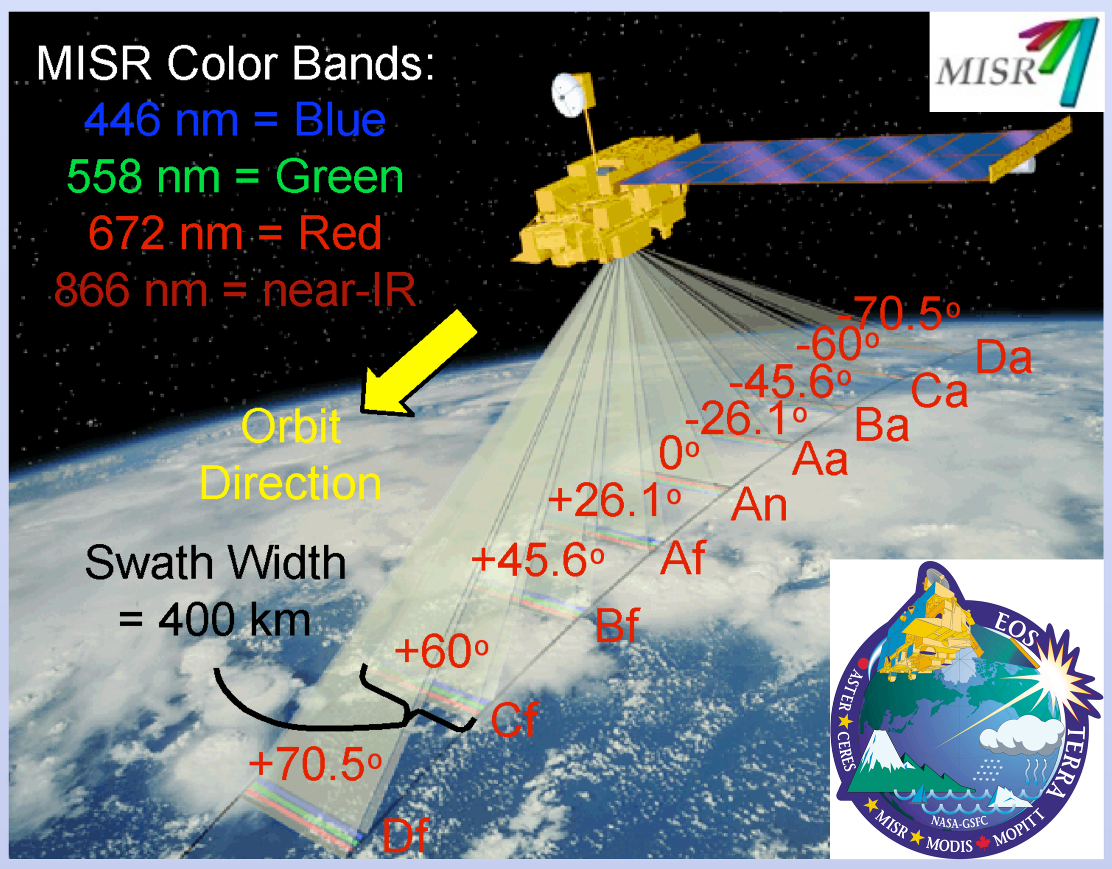
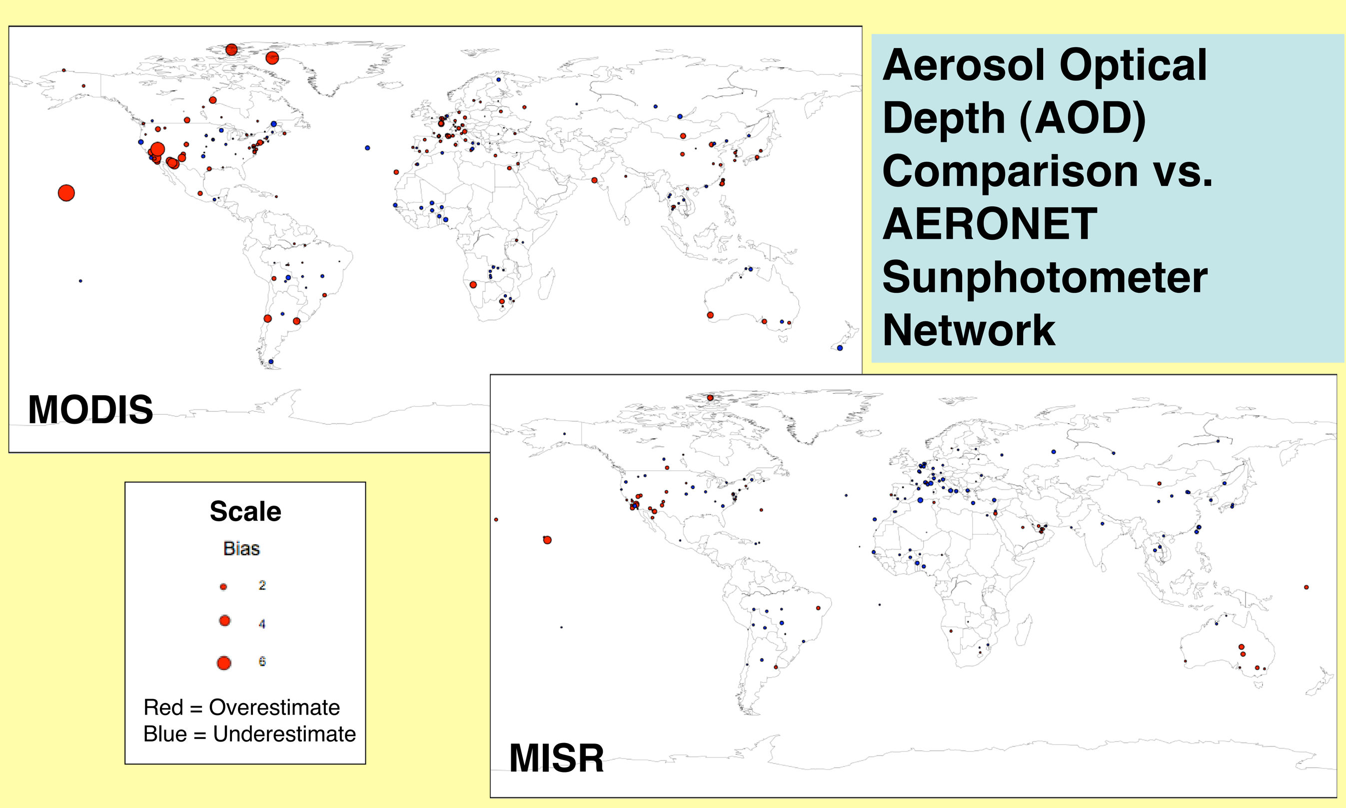
Abstract: The OMI instrument on Aura has successfully demonstrated the ability to provide high spatial resolution information regarding significant sources of near-surface SO_2 including anthropogenic sources such as smelters and power plants. The Multi-angle Imaging SpectroRadiometer (MISR) instrument on the Terra satellite can likewise provide high spatial resolution information regarding aerosol optical depth and particle properties over land and ocean. Aerosol optical depth, in turn, can be related to estimates of surface PM 2.5. Taking advantage of the temporal offset between Aura and Terra, we will describe the observed relationships between OMI SO_2 and MISR aerosol optical depth, as well as estimates of surface PM 2.5. We will focus on a case study of the large copper smelter in Ilo, Peru that drastically reduced its sulfur emissions in early 2007.



The Multi-angle Imaging SpectroRadiometer (MISR) instrument on the Terra satellite has spatial sampling as high as 275 m. Aerosol optical depth and particle type retrievals are performed globally at 17.6 km x 17.6 km resolution over land and water.
Image courtesy of Shigeru Suzuki and Eric M. De Jong. Solar System Visualization Project. JPL image P-49081.



Global comparisons of MISR aerosol optical depth and AERONET sunphotometer direct beam measurements show good agreement for both MISR and MODIS over land, with MISR having slightly lower bias in some locations, particularly the western United States.
Figures courtesy Susan Paradise (JPL).

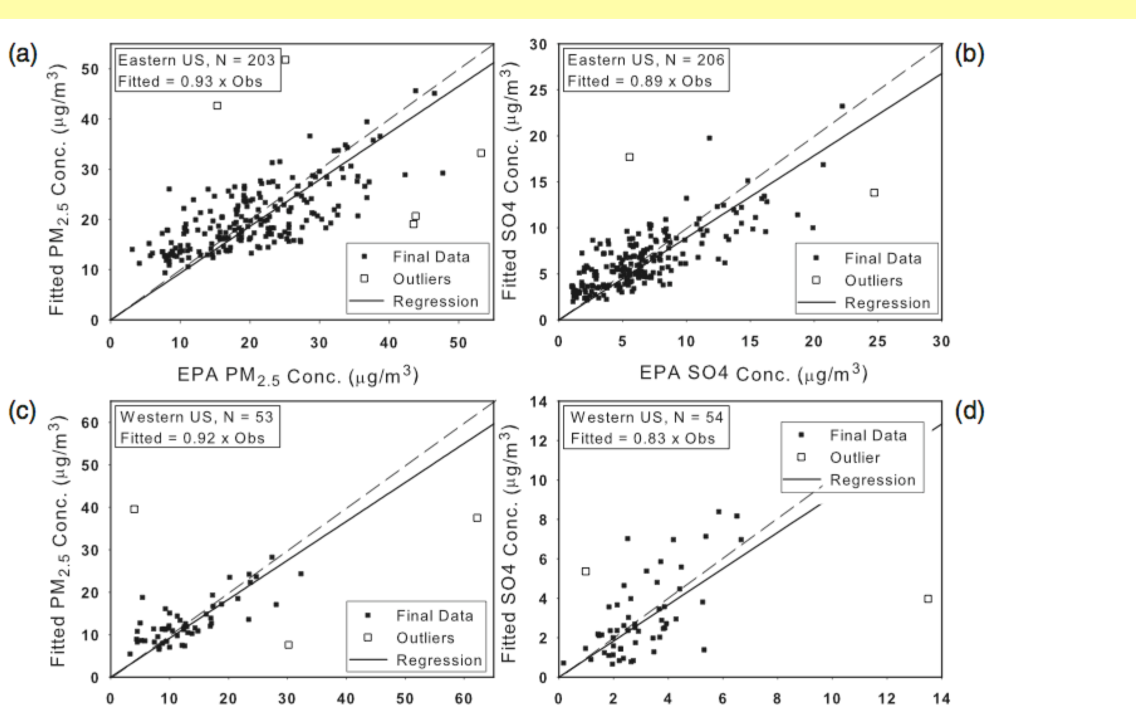
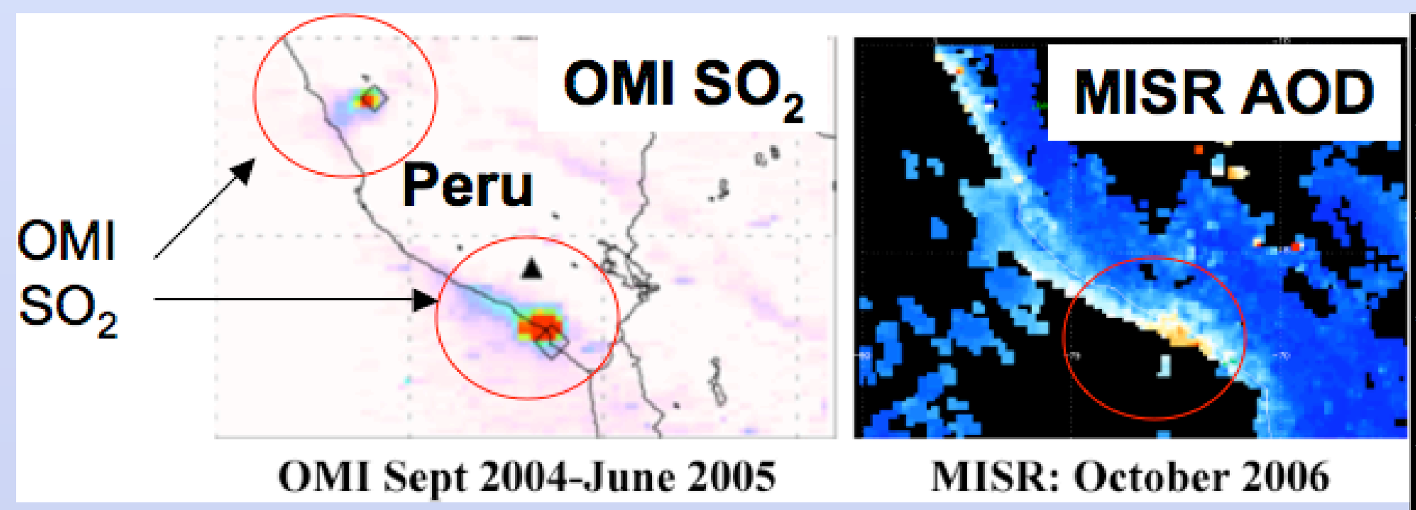


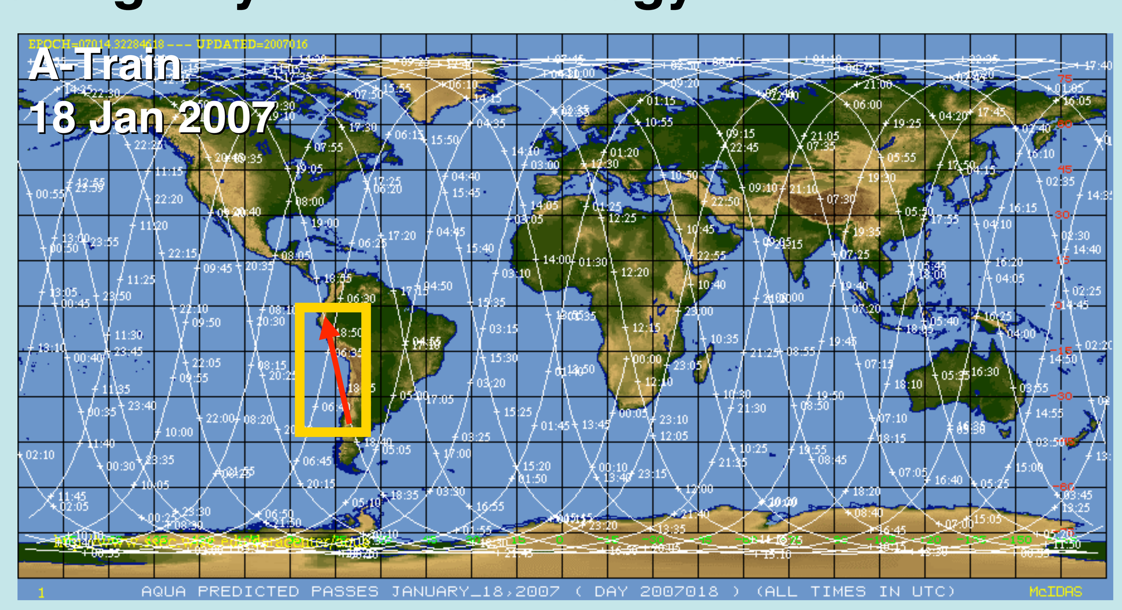
Figure 2. Scatterplots of fitted $PM_{2.5}$ mass in (a) the eastern and (c) western United States, and SO_4 concentrations versus EPA observations in (b) the eastern and (d) western United States. Solid lines represent simple linear regression results with intercepts excluded. The 1:1 lines are displayed as dashed lines for reference. Final data used to derive the regression coefficients are displayed as small black squares and outliers are displayed as large hollow squares.

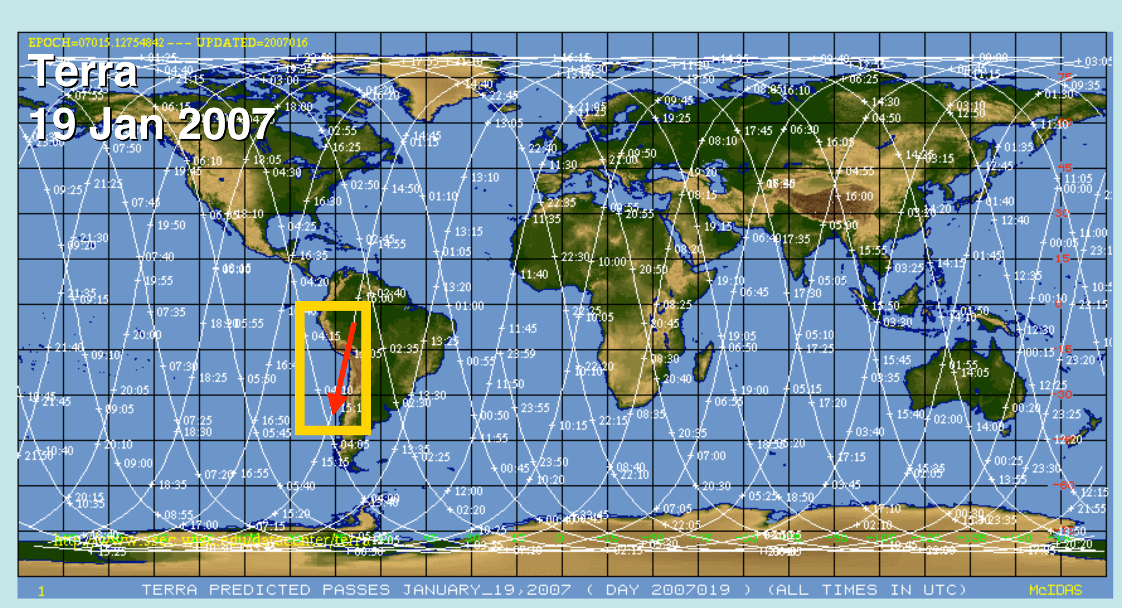
Work by Yang Liu (Harvard) and collaborators (Liu et al. 2007a,b) shows that regression models using MISR fractional optical depth are better able to predict surface PM 2.5 and SO_4 concentrations than models using total optical depth, particularly in the western United States.
Figure from Liu et al. (2007b)



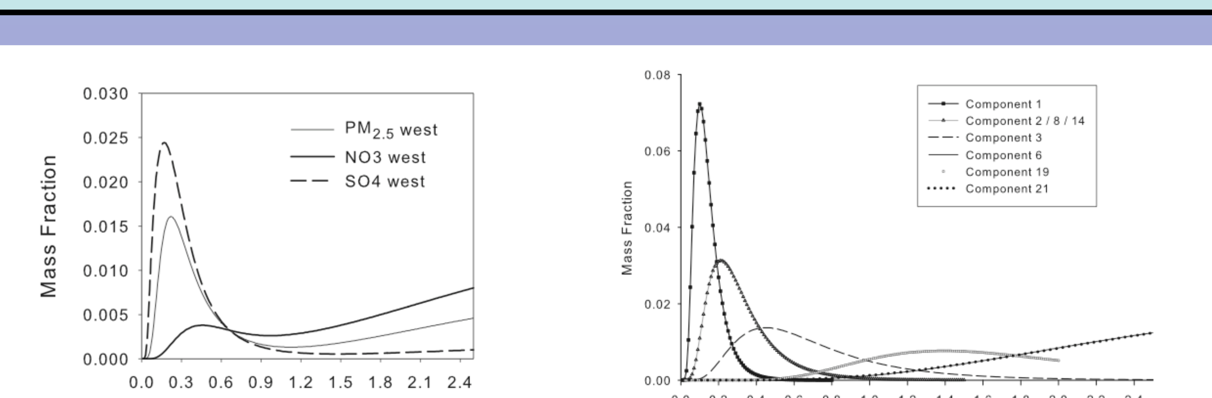
High spatial resolution climatologies of SO_2 from OMI show the presence of significant source regions in Peru (Carn et al., 2007). Monthly climatologies of aerosol optical depth from MISR show associated regions of high AOD (and likely high surface PM 2.5).
Image on left from Carn et al. (2007).

Moving Beyond Climatology



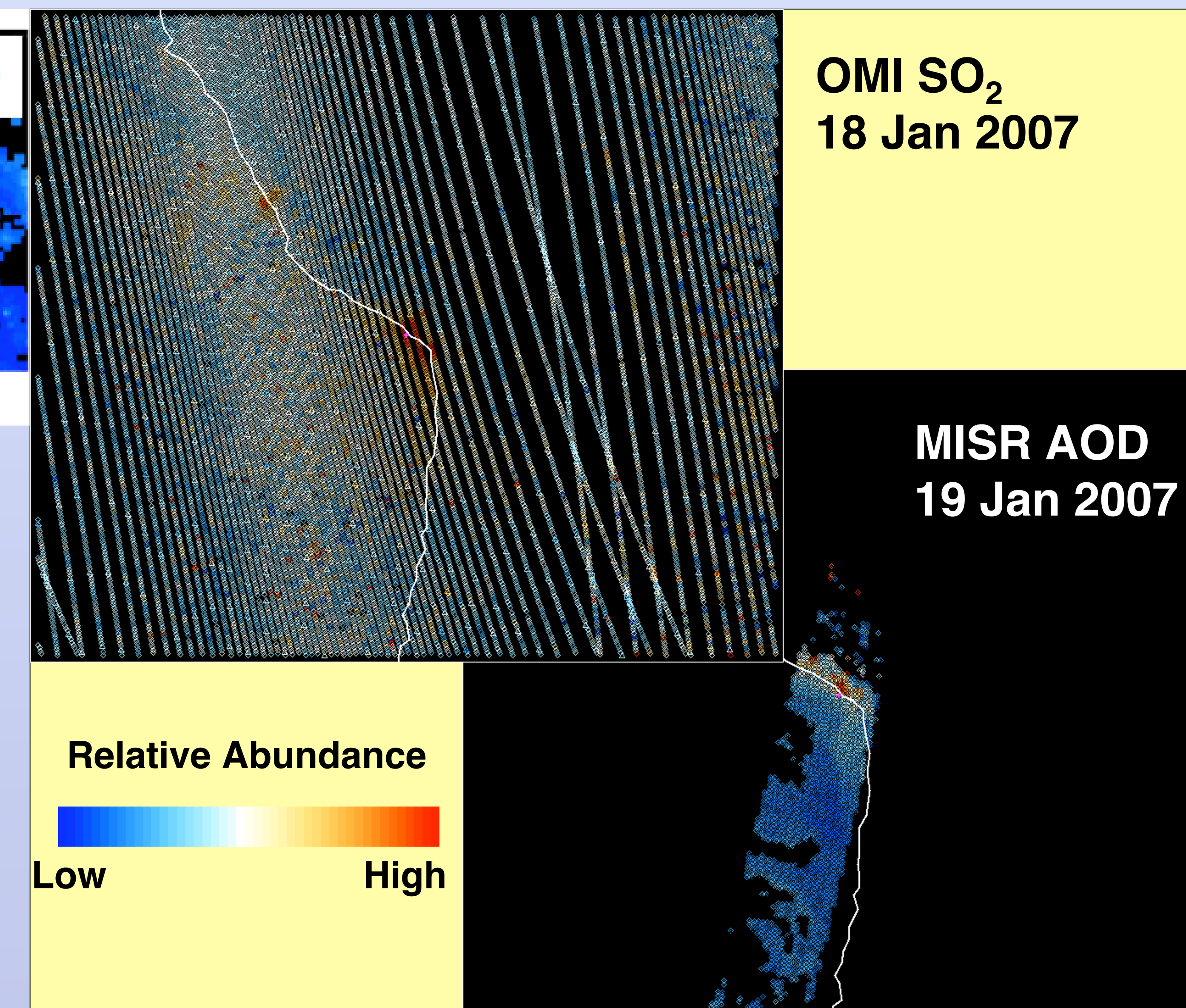


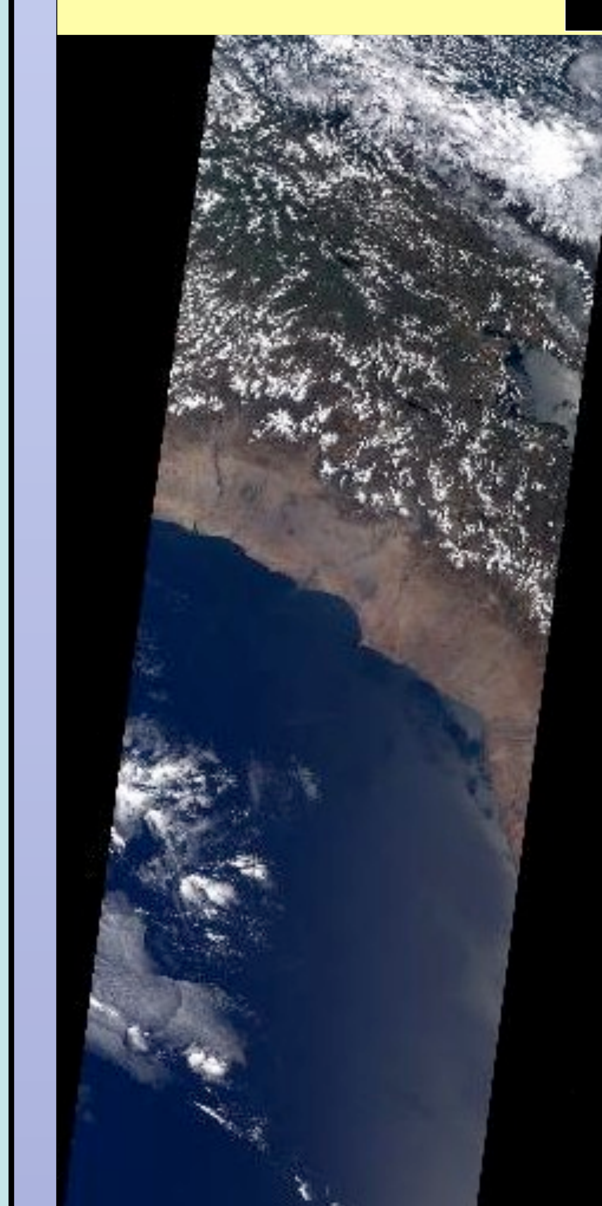
The orbit characteristics of the A-Train and Terra are such that some locations are seen by A-Train instruments on their ascending (daytime) overpass and by the Terra instruments on a later descending (daytime) overpass. In the figures above, the orbit direction is indicated by the red arrow and the yellow box indicates a region of overlap. These overlaps repeat nearly exactly every 16 days, which is the repeat cycle of both Terra and the A-Train. The time difference in this box is ~ 20 hr 15 min. The temporal difference is advantageous when considering conversion of gaseous SO_2 observable by OMI on the A-Train to particulate SO_4 which is an aerosol component observable by MISR on Terra.

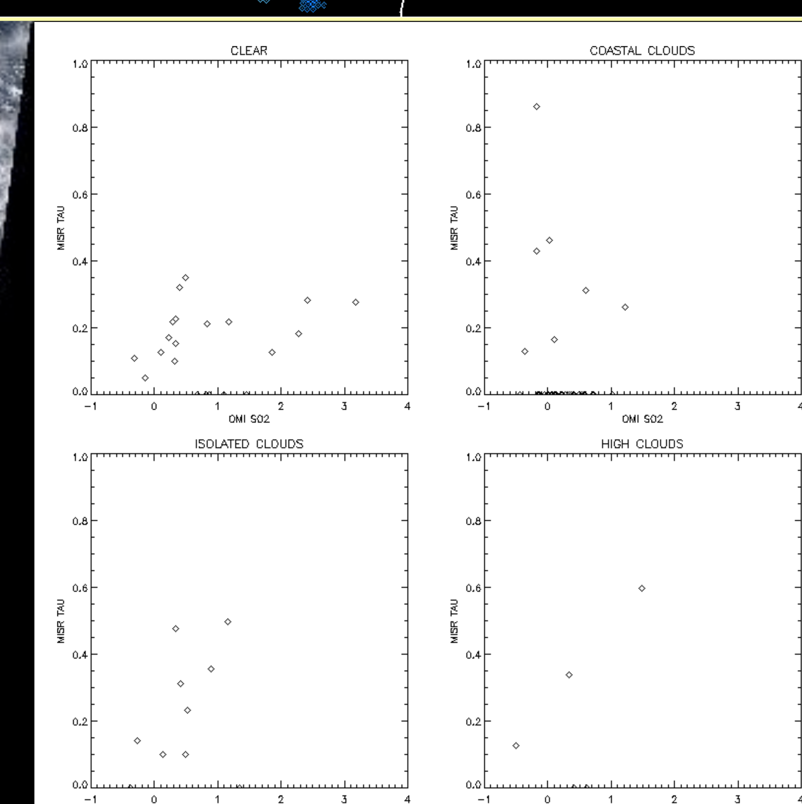


Comparison of climatological particle size distributions for the western U.S. (left) and the MISR pure aerosol particles (right) from Liu et al. (2007a, 2007b)

This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.







Comparisons of OMI SO2 and time lagged MISR total AOD show good agreement, but also reveal dependence on cloud regime.

References:

Carn, S. A., A. J. Krueger, N. A. Krotkov, K. Yang, and P. F. Levelt (2007), Sulfur dioxide emissions from Peruvian copper smelters detected by the Ozone Monitoring Instrument, *Geophysical Research Letters, 34*, L09801, doi:10.1029/2006GL029020.

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